Association of Resident Fatigue and Distress With Occupational Blood and Body Fluid Exposures and Motor Vehicle Incidents

Colin P. West, MD, PhD; Angelina D. Tan, BS, BA; and Tait D. Shanafelt, MD

Abstract

Objective: To evaluate the effect of resident physicians' distress on their personal safety.

Participants and Methods: We conducted a prospective, longitudinal cohort study of internal medicine residents at Mayo Clinic in Rochester, Minnesota. Participants completed surveys quarterly from July 1, 2007, through July 31, 2011, during their training period. Frequency of self-reported blood and body fluid (BBF) exposures and motor vehicle incidents was recorded. Associations of validated measures of quality of life, burnout, symptoms of depression, fatigue, and sleepiness with a subsequently reported BBF exposure or motor vehicle incident were determined using generalized estimating equations for repeated measures.

Results: Data were provided by 340 of 384 eligible residents (88.5%). Of the 301 participants providing BBF exposure data, 23 (7.6%) reported having at least 1 BBF exposure during the study period. Motor vehicle incidents were reported by 168 of 300 respondents (56.0%), including 34 (11.3%) reporting a motor vehicle crash and 130 (43.3%) reporting a near-miss motor vehicle crash. Other than the low personal accomplishment domain of burnout, distress and fatigue at one time point exhibited no statistically significant associations with BBF exposure in the subsequent 3 months. However, diminished quality of life, burnout, positive screening for depression, fatigue, and sleepiness were each associated with statistically significantly increased odds of reporting a motor vehicle incident in the subsequent 3 months.

Conclusion: Exposures to BBF are relatively uncommon among internal medicine residents in current training environments. Motor vehicle incidents, however, remain common. Our results confirm the importance of fatigue and sleepiness to resident safety concerns. In addition, higher levels of distress may be contributory factors to motor vehicle crashes and other related incidents. Interventions designed to address both fatigue and distress may be needed to optimally promote patient and resident safety.

 ■ Mayo Clin Proc. 2012;87(12):1138-1144

See editorial comment, page 1135

From the Division of General Internal Medicine (C.P.W.), Division of Biomedical Statistics and Informatics (C.P.W., A.D.T.), and Division of Hematology (T.D.S.), Mayo Clinic, Rochester, MN.

Research during the past decade has established that fatigue and distress, including burnout, depression, and low quality of life (QOL), among physicians are common during and beyond training.[1-5] Numerous studies suggest that fatigue and sleepiness contribute to medical errors.[6-10] Resident distress also contributes to self-reported major medical errors,[11,12] medication errors,[13] suboptimal care practices,[14] and decreased patient satisfaction with medical care.[15] Thus, both fatigue and distress appear to negatively affect patient safety.

Beyond its potential repercussions for patients, fatigue has also been linked to physicians' personal safety.[16] Extended work duration and related fatigue are associated with increased risk of motor vehicle crashes (MVCs) and near-miss MVCs.[17] Furthermore, strong associations of extended work duration and fatigue with percutaneous blood and body fluid (BBF) exposures[18] and sharps injuries[19] have been reported.

Less well understood is the potential effect of distress on physicians' personal safety. Therefore, we used the prospective, longitudinal Mayo Internal Medicine Well-being Study to evaluate the associations of distress, fatigue, and sleepiness with occupational BBF exposures and motor vehicle incidents.

PARTICIPANTS AND METHODS

Study Participants

All categorical and preliminary internal medicine residents in the Mayo Clinic Rochester Internal Medicine Residency Program from July 1, 2007, through July 31, 2011, were invited to participate in this study. Program structure and study enrollment procedures have been detailed previously.[11] Written informed consent was obtained for all participants. The Mayo Clinic Institutional Review Board approved this study.

Data Collection

Residents were surveyed via e-mail every 3 months throughout the study period. Surveys were administered quarterly by the Mayo Clinic Survey Re-

Mayo Clin Proc. ■ December 2012;87(12):1138-1144 ■ http://dx.doi.org/10.1016/j.mayocp.2012.07.021
www.mayoclinicproceedings.org ■ © 2012 Mayo Foundation for Medical Education and Research

search Center (summer: July and August; fall: October and November; winter: January and February; spring: April and May). Participants were given approximately 10 days to complete each survey.

Surveys included questions about demographic and current rotation characteristics, coping strategies for dealing with stress, report of BBF exposures, and report of involvement in MVCs or near-miss MVCs (as the driver) or falling asleep while driving or stopped in traffic. Validated survey tools were used to measure fatigue, sleepiness, QOL, burnout, and symptoms of depression. Burnout and symptoms of depression were evaluated every 6 months, whereas self-reported BBF exposures and motor vehicle incidents, QOL, linear analog self-assessment of fatigue, and Epworth Sleepiness Scale score were assessed quarterly. Data through July 2011 were analyzed. No member of the Mayo Clinic Department of Medicine had access to identifying information on study items for individual participants.

Study Measures

Self-Reported BBF Exposures and Motor Vehicle Incidents. The BBF exposures were evaluated by asking residents, "In the last 3 months, have you personally had an occupational exposure to potentially contaminated blood or other body fluid?" Residents indicating that a BBF exposure had occurred were asked whether the exposure was reported to the occupational health service and about factors they thought contributed to the exposure, including fatigue. Motor vehicle incidents were evaluated by asking the following: (1) "In the last 3 months, have you personally (as the driver) been involved in a motor vehicle accident?" (2) "In the last 3 months, have you personally (as the driver) been involved in a near-miss motor vehicle accident?" (3) "In the last 3 months, have you nodded off or fallen asleep while driving?" and (4) "In the last 3 months, have you nodded off or fallen asleep while stopped in traffic?" These questions are similar to those used in prior research on BBF exposures[18] and motor vehicle incidents.[17]

Fatigue and Sleepiness. Fatigue and sleepiness are related but distinct concepts.[20,21] Fatigue typically reflects a broader sense of diminished energy, whereas sleepiness refers to a reduced level of alertness. In this study, fatigue was evaluated using a standardized, linear analog self-assessment question, and sleepiness was assessed using the Epworth Sleepiness Scale.[22,23] Respondents reported their level of fatigue during the previous week on a 0- to 10-point scale, with response anchors ranging from "as bad as it can be" (0 points) to "as good as it can be" (10 points). Therefore, worsening fatigue is indicated by lower fatigue scores. The Epworth Sleepiness Scale evaluates an individual's recent level of daytime sleepiness using 8 scenarios scored on a Likert scale from 0 ("no chance of dozing") to 3 ("high chance of dozing").[22,23] A score of at least 10 suggests excessive daytime sleepiness.

QOL, Burnout, and Depression. Resident QOL was measured by a single-item, linear analog self-assessment scale. This instrument assesses overall QOL on a 0- to 10-point scale, with the same anchors as the fatigue question. Scores of 5 or less correlate with poor outcomes in clinical studies.[24] This scale has been widely validated across multiple medical conditions and populations.[25-27] In addition, we applied the Medical Outcomes Study Short-Form Health Survey, which has 8 items with 5- and 6-point Likert scales. This instrument generates norm-based scores, calibrated to a mean score of 50, which are assigned to domains of mental and physical health.[28]

Burnout is a syndrome comprising 3 domains (depersonalization, emotional exhaustion, and a sense of low personal accomplishment) that are associated with decreased work performance.[29] Burnout was measured using the Maslach Burnout Inventory,[29] in which responders rate the frequency with which they experience various feelings or emotions on a 7-point Likert scale, with response options ranging from "never" to "daily." Higher scores for depersonalization and emotional exhaustion and lower scores for personal accomplishment signify burnout. This instrument has been applied in numerous prior studies of physicians.[2,14,30,31]

Depression screening used the 2-question strategy described by Spitzer et al[32] and validated by Whooley et al.[33] This tool has been used in a number of patient populations,[32,33] including studies of physicians.[11,14] This instrument asks questions about depressed mood and anhedonia: (1) "During the past month, have you often been bothered by feeling down, depressed, or hopeless?" and (2) "During the past month, have you often been bothered by little interest or pleasure in doing things?" A positive screen for depression is defined as a "yes" response to either question. As discussed previously,[11] this screening approach performs favorably relative to other depression screening instruments.[33,34]

Statistical Analyses

Standard univariate statistics were used to describe the sample. The association of QOL, burnout, depression, and fatigue with subsequent self-reported BBF exposure and motor vehicle incidents was analyzed using generalized estimating equations, an extension of generalized linear models that allows for correlated repeated measurements within individuals.[35,36] An exchangeable correlation structure was specified for these models.

Analyses were performed examining the association of distress and fatigue with the likelihood of a self-reported BBF exposure or motor vehicle incident during the following 3 months, as reported at the subsequent survey time point. Thus, the assessment of all distress variables occurred before the self-reported BBF exposures and motor vehicle incidents. Statistical analyses were conducted using SAS statistical software, version 9.2 (SAS Institute Inc). Statistical significance was set at the .05 level, and all tests were 2-tailed.

RESULTS

Participants were 340 of 384 internal medicine residents (88.5%) in training at Mayo Clinic from July 1, 2007, through July 31, 2011. There were no statistically significant differences between participants and nonparticipants regarding age, sex, or program type. The demographic characteristics of study participants are displayed in Table 1. Of the participants, 301 (88.5%) completed at least 1 survey and 83 (24.4%) completed all surveys (up to 13 quarterly surveys) during the study period, with a mean response rate to individual surveys of 60.8% (range, 50.0%-73.2%). Participant characteristics for QOL, burnout, depression, fatigue, and sleepiness are detailed in Table 2.

TABLE 1. Demographic Characteristics of the 340 Participants at the Time of Study Entry[a]

Characteristic	No. (%) of participants
Age	
≤30 y	209 (84.3)
>30 y	39 (15.7)
Sex	
Male	208 (61.2)
Female	132 (38.8)
Program	
Categorical	263 (77.4)
Preliminary	77 (22.6)
Student loan debt	
<$50,000	90 (32.4)
$50,000-$100,000	26 (9.4)
>$100,000	162 (58.3)
Relationship status	
Single	109 (38.2)
Married	146 (51.2)
Divorced	2 (0.7)
Partner	28 (9.8)
Children at home	
Yes	54 (18.9)
No	231 (81.1)

[a] Numbers may not total to 340 because of missing data.

Overall, BBF exposures were reported by 23 study participants (7.6%) during the study period, with 4 participants reporting exposures in 2 study quarters. Only 9 of the 24 exposures (37.5%) for which further data were provided were reported to the occupational health service, and only 3 of these 24 exposures were self-identified as being related to fatigue. Motor vehicle incidents were reported by 168 respondents (56.0%), including 34 (11.3%) reporting an MVC, 130 (43.3%) reporting a near-miss MVC, 60 (20.0%) reporting falling asleep while driving, and 53 (17.7%) reporting falling asleep while stopped in traffic.

Associations between fatigue and distress at each time point and a BBF exposure or motor vehicle incident in the subsequent 3 months are given in Table 3. Each 1-point decrease in personal accomplishment was associated with an 8% increase in the odds of a self-reported BBF exposure in the subsequent 3 months. No other associations were observed with BBF exposures.

Increased fatigue and sleepiness were predictive of increased odds of reporting any motor vehicle incident in the subsequent 3 months. Each 1-point increase in fatigue or Epworth Sleepiness Scale score was associated with a 10% increase in these odds. Increased fatigue and sleepiness were also associated with increased odds of reporting an MVC in the subsequent 3 months. Each 1-point increase in fatigue or Epworth Sleepiness Scale score was associated with a 52% and 12% increase in these odds, respectively. The odds ratios for an MVC or any motor vehicle incident associated with a worsening in fatigue from an optimal score of 10 to a score of 5 were 8.07 and 1.58, respectively. The odds ratios for an MVC or any motor vehicle incident associated with an increase in Epworth Sleepiness Scale score from 5 to 15 (indicative of excessive daytime sleepiness) were 3.05 and 2.51, respectively.

Because one Epworth Sleepiness Scale item overlaps with self-report of falling asleep while stopped in traffic, sensitivity analyses using a modified Epworth Sleepiness Scale score excluding this item were performed. These analyses yielded nearly identical results to those using the complete Epworth Sleepiness Scale.

Diminished QOL in multiple domains, higher levels of emotional exhaustion and depersonalization, and positive screening for depression were also each predictive of increased odds of reporting any motor vehicle incident in the subsequent 3 months. For example, each 1-point decrease in overall QOL was associated with a 29% increase in the odds of an MVC and a 13% increase in the odds of any motor vehicle incident. Thus, the odds ratios for an MVC or any motor vehicle incident associated with a decrease in overall QOL from a maximum score of 10 to a poor score of 5 were 3.57 and 1.87, respectively. Each 1-point increase in emotional exhaustion or depersonalization was associated with a 3% and 4% increase, respectively, in the odds of reporting any motor vehicle incident. The odds ratio for any motor vehicle incident associated with a worsening of emotional exhaustion from a low score of 15 to a high score of 30 was 1.64 and that associated with a worsening of depersonalization from a low score of 5 to a high score of 15 was 1.54. A positive depression screen was associated with a 2.11-fold increased odds of a self-reported motor vehicle incident in the following 3 months.

Although not statistically significant, the risk of any motor vehicle incident was slightly higher among first-year residents and residents on inpatient rotations. However, the associations between motor vehicle incidents and distress, fatigue, and sleepiness were not significantly altered by the addition to these models of several potential confounding factors, including categorical or preliminary resident status, type of rotation at the time of each survey, postgraduate year, and sex.

TABLE 2. Average Fatigue, Sleepiness, and Distress of Participants During the Study Period, 2007-2011[a]

Metric (scale)	No. of participants	Mean (SD) score
Overall QOL		
LASA overall QOL (score, 0-10)	301	6.47 (1.51)
Mental well-being		
SF-8 mental (score, 0-100)	273	46.14 (8.03)
LASA mental QOL (score, 0-10)	301	6.54 (1.49)
Physical well-being		
SF-8 physical (score, 0-100)	273	53.17 (4.73)
LASA physical QOL (score, 0-10)	301	6.05 (1.58)
Emotional well-being		
LASA emotional QOL (score, 0-10)	301	6.20 (1.71)
Depression		
Positive 2-item screen result	278	43.88% (49.71%)
Burnout[b]		
MBI-EE (score, 0-54)	277	23.34 (10.65)
MBI-DP (score, 0-30)	277	8.88 (5.64)
MBI-PA (score, 0-48)	276	37.65 (6.08)
Fatigue and sleepiness[c]		
LASA fatigue (score, 0-10)	301	5.26 (1.62)
ESS (score, 0-24)	299	8.79 (4.05)

[a] ESS = Epworth Sleepiness Scale; LASA = linear analog self-assessment; MBI-DP = Maslach Burnout Inventory–depersonalization; MBI-EE = Maslach Burnout Inventory–emotional exhaustion; MBI-PA = Maslach Burnout Inventory–personal accomplishment; QOL = quality of life; SF-8 = Medical Outcomes Study Short-Form Health Survey.

[b] Higher depersonalization or emotional exhaustion scores and lower personal accomplishment scores are indicative of greater burnout. Thresholds to categorize physicians as having low, average, or high burnout are determined on the basis of normative scale scores[29]: emotional exhaustion: low burnout, 0 through 18; average burnout, 19 through 26; and high burnout 27 or higher; depersonalization: low burnout, 0 through 5; average burnout, 6 through 9; high burnout, 10 or higher; and personal accomplishment: low burnout, 40 or higher; average burnout, 34 through 39; and high burnout, 0 through 33.

[c] Lower LASA fatigue score means greater fatigue, with 0 indicating "as bad as it can be" and 10 indicating "as good as it can be".

DISCUSSION

The results of this 5-year, prospective, longitudinal cohort study confirm the importance of fatigue and sleepiness to resident safety concerns, particularly relating to motor vehicle incidents. In addition, however, higher levels of personal distress may also be contributory factors to MVCs and other motor vehicle incidents. These findings indicate that resident distress is related not only to patient safety and quality of care but to residents' personal safety as well.

Rates of BBF exposure were reassuringly low in our study. However, when BBF exposures occurred, most were not reported to occupational health services. This finding is consistent with prior research[18,37,38] and suggests that further work is needed to ensure proper evaluation and management of these exposures when they occur in trainees. Because of the low rates observed in our study, it is not possible to definitively rule out associations of distress with BBF exposures. However, even if present the absolute effect of such associations appears likely to be small.

On the other hand, the observed associations of distress, fatigue, and sleepiness with subsequent MVCs and related incidents are of a magnitude sufficient to meaningfully affect resident safety and possibly affect public safety if the motor vehicle incidents involve others. Given the relatively high baseline occurrence rates of these events, the odds ratios associated with differences in distress and fatigue from low to high levels would be associated with substantial increases in the risk of motor vehicle incidents.

Excessive resident fatigue and sleepiness have been the primary focus of duty hour reforms and the most recent Institute of Medicine recommendations to protect both patients and residents.[7,16,39,40] However, the current findings suggest that targeted efforts to reduce burnout and depression and improve resident QOL should also be part of graduate medical education reforms. The most effective strat-

TABLE 3. Association of Fatigue, Sleepiness, Quality of Life, Burnout, and Symptoms of Depression with BBF Exposures and Motor Vehicle Incidents in the Following 3 Months[a,b]

	BBF exposure		MVC		Near-miss MVC		Asleep while driving		Asleep while stopped in traffic		Any motor vehicle incident	
Outcome	OR (95% CI)[c]	*P* value	OR (95% CI)[c]	*P* value	OR (95% CI)[c]	*P* value	OR (95% CI)[c]	*P* value	OR (95% CI)[c]	*P* value	OR (95% CI)[c]	*P* value
Overall QOL												
LASA overall QOL (0- to 10-point scale)	1.14 (0.89-1.46)	.29	1.29 (1.06-1.57)	.01	1.13 (1.04-1.22)	.004	1.02 (0.89-1.17)	.74	1.06 (0.94-1.19)	.33	1.13 (1.05-1.22)	.001
Mental well-being												
SF-8 (0- to 100-point scale)	1.01 (0.92-1.11)	.82	1.05 (0.99-1.10)	.08	1.04 (1.01-1.06)	.003	1.03 (1.00-1.07)	.03	1.01 (0.98-1.04)	.66	1.03 (1.01-1.05)	.001
LASA mental QOL (0- to 10-point scale)	0.98 (0.78-1.22)	.84	1.32 (1.11-1.57)	.002	1.20 (1.11-1.29)	<.001	1.03 (0.91-1.16)	.67	1.03 (0.92-1.16)	.57	1.19 (1.11-1.28)	<.001
Physical well-being												
SF-8 (0- to 100-point scale)	0.97 (0.89-1.07)	.56	1.16 (1.08-1.25)	<.001	1.04 (1.00-1.08)	.05	1.04 (0.99-1.09)	.08	1.04 (0.98-1.09)	.19	1.06 (1.03-1.09)	<.001
LASA physical QOL (0- to 10-point scale)	1.06 (0.85-1.33)	.59	1.34 (1.06-1.70)	.01	1.04 (0.97-1.13)	.27	1.05 (0.93-1.19)	.42	1.10 (0.95-1.27)	.20	1.09 (1.02-1.18)	.02
Emotional well-being												
LASA emotional QOL (0- to 10-point scale)	1.11 (0.91-1.35)	.32	1.23 (1.04-1.46)	.02	1.15 (1.07-1.23)	<.001	1.04 (0.93-1.16)	.52	1.01 (0.90-1.14)	.84	1.15 (1.08-1.23)	<.001
Depression												
Positive 2-item screen	1.12 (0.19-6.50)	.90	1.80 (0.62-5.27)	.28	1.96 (1.28-3.01)	.002	2.75 (1.35-5.60)	.005	1.05 (0.55-2.03)	.87	2.11 (1.49-3.01)	<.001
Burnout												
MBI-EE	1.04 (0.97-1.12)	.29	1.04 (0.99-1.08)	.12	1.04 (1.02-1.07)	<.001	1.01 (0.98-1.04)	.46	0.98 (0.96-1.01)	.31	1.03 (1.01-1.05)	.001
MBI-DP	1.00 (0.91-1.09)	.95	1.04 (0.96-1.13)	.33	1.05 (1.01-1.09)	.01	1.02 (0.96-1.09)	.48	0.97 (0.91-1.04)	.42	1.04 (1.01-1.08)	.02
MBI-PA	1.08 (1.04-1.12)	<.001	1.09 (1.01-1.17)	.03	0.99 (0.95-1.03)	.59	1.02 (0.96-1.08)	.50	0.99 (0.92-1.05)	.66	1.01 (0.98-1.04)	.65
Fatigue and sleepiness												
LASA fatigue (0- to 10-point scale)	0.98 (0.80-1.19)	.80	1.52 (1.26-1.83)	<.001	1.07 (1.01-1.15)	.04	0.99 (0.89-1.10)	.87	1.05 (0.95-1.17)	.31	1.10 (1.03-1.16)	.003
ESS (0- to 24-point scale)	1.00 (0.91-1.10)	.97	1.12 (1.02-1.23)	.02	1.07 (1.03-1.12)	.002	1.11 (1.04-1.19)	.003	1.10 (1.04-1.16)	<.001	1.10 (1.06-1.14)	<.001

[a]BBF = blood and body fluid; ESS = Epworth Sleepiness Scale; LASA = linear analog self-assessment; MBI-DP = Maslach Burnout Inventory-depersonalization; MBI-EE = Maslach Burnout Inventory–emotional exhaustion; MBI-PA = Maslach Burnout Inventory–personal accomplishment; MVC = motor vehicle crash; OR = odds ratio; QOL = quality of life; SF-8 = Medical Outcomes Study Short-Form Health Survey.
[b]Using generalized estimating equation models adjusted for time.
[c]The OR (95% CI) of an event in the following 3 months associated with a 1-unit worsening in each metric's score (ie, increase in burnout domain scores and ESS and decrease in LASA items and SF-8 domains).

egies for achieving these goals are unknown and should be the subject of future study.

This study has several limitations. First, the degree to which the self-reported BBF exposures and motor vehicle incidents in this study accurately reflect true events cannot be determined. Second, the generalizability of these results to other training programs is unclear. However, the participation and survey response rates were favorable relative to other physician surveys,[41] and the BBF exposure[18,37,38] and MVC rates,[17] burnout scores,[2,14,30,31] rates of a positive depression screen,[14] and fatigue levels[42,43] found in this study were similar to those found in prior studies of medical residents and junior physicians at other institutions. Third, multicollinearity limited our ability to conduct multivariable analyses containing multiple distress or fatigue variables. For example, it is possible that the observed relationships between distress and motor vehicle incidents are mediated by fatigue, although prior research has suggested independent roles of distress and fatigue for other outcomes.[12] Further study will be necessary to provide insight into the independent effects of individual well-being variables on resident safety and into the separate effects of fatigue and sleepiness.

CONCLUSION

Exposures to BBF are relatively uncommon among internal medicine residents in current training environments. Motor vehicle incidents, however, remain common. Our results suggest that fatigue, sleepiness, burnout, depression, and reduced QOL are associated with an increased risk of future motor vehicle incidents. In addition to ongoing efforts to limit physician fatigue and sleepiness, interventions to promote well-being and reduce distress among physicians are needed to improve both patient and resident safety.

Abbreviations and Acronyms: **BBF** = blood and body fluid; **MVC** = motor vehicle crash; **QOL** = quality of life

Grant Support: This work was supported by the Mayo Clinic Department of Medicine Program on Physician Well-being.

Role of the Sponsor: The funding source played no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation of the manuscript.

Correspondence: Address to Colin P. West, MD, PhD, Division of General Internal Medicine, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (west.colin@mayo.edu).

REFERENCES

1. Shanafelt TD, Sloan JA, Habermann TM. The well-being of physicians. *Am J Med*. 2003;114(6):513-519.
2. Thomas NK. Resident burnout. *JAMA*. 2004;292(23):2880-2889.
3. Dyrbye LN, Thomas MR, Massie FS, et al. Burnout and suicidal ideation among U.S. medical students. *Ann Intern Med*. 2008;149(5):334-341.
4. Shanafelt TD, Balch CM, Bechamps G, et al. Burnout and medical errors among American surgeons. *Ann Surg*. 2010;251(6):995-1000.
5. West CP, Shanafelt TD, Kolars JC. Quality of life, burnout, educational debt, and medical knowledge among internal medicine residents. *JAMA*. 2011;306(9):952-960.
6. Kohn LT, Corrigan JM, Donaldson MS, eds. *To Err Is Human: Building a Safer Health System*. Washington, DC: National Academy Press; 1999.
7. Landrigan CP, Rothschild JM, Cronin JW, et al. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med*. 2004;351(18):1838-1848.
8. Barger LK, Ayas NT, Cade BE, et al. Impact of extended-duration shifts on medical errors, adverse events, and attentional failures. *PLoS Med*. 2006;3(12):e487.
9. Lockley SW, Barger LK, Ayas NT, Rothschild JM, Czeisler CA, Landrigan CP. Effects of health care provider work hours and sleep deprivation on safety and performance. *Jt Comm J Qual Patient Saf*. 2007;33(11, suppl):7-18.
10. Agency for Healthcare Research and Quality. Making health care safer: a critical analysis of patient safety practices. 2001. http://www.ahrq.gov/clinic/ptsafety/. Accessed April 5, 2012.
11. West CP, Huschka MM, Novotny PJ, et al. Association of perceived medical errors with resident distress and empathy: a prospective longitudinal study. *JAMA*. 2006;296(9):1071-1078.
12. West CP, Tan AD, Habermann TM, Sloan JA, Shanafelt TD. Association of resident fatigue and distress with perceived medical errors. *JAMA*. 2009;302(12):1294-1300.
13. Fahrenkopf AM, Sectish TC, Barger LK, et al. Rates of medication errors among depressed and burnt out residents: prospective cohort study. *BMJ*. 2008;336(7642):488-491.
14. Shanafelt TD, Bradley KA, Wipf JE, Back AL. Burnout and self-reported patient care in an internal medicine residency program. *Ann Intern Med*. 2002;136(5):358-367.
15. Haas JS, Cook EF, Puopolo AL, Burstin HR, Cleary PD, Brennan TA. Is the professional satisfaction of general internists associated with patient satisfaction? *J Gen Intern Med*. 2000;15(2):122-128.
16. Institute of Medicine. *Resident Duty Hours: Enhancing Sleep, Supervision, and Safety*. Washington, DC: Institute of Medicine, 2008. http://www.iom.edu/Reports/2008/Resident-Duty-Hours-Enhancing-Sleep-Supervision-and-Safety.aspx. Accessed April 5, 2012.
17. Barger LK, Cade BE, Ayas NT, et al. Extended work shifts and the risk of motor vehicle crashes among interns. *N Engl J Med*. 2005;352(2):125-134.
18. Ayas NT, Barger LK, Cade BE, et al. Extended work duration and the risk of self-reported percutaneous injuries in interns. *JAMA*. 2006;296(9):1055-1062.
19. Fisman DN, Harris AD, Rubin M, Sorock S, Mittleman MA. Fatigue increases the risk of injury form sharp devices in medical trainees: results from a case-crossover study. *Infect Control Hosp Epidemiol*. 2007;28(1):10-17.
20. Pigeon WR, Sateia MJ, Ferguson RJ. Distinguishing between excessive daytime sleepiness and fatigue: toward improved detection and treatment. *J Psychosom Res*. 2003;54(1):61-69.
21. Shen J, Barbera J, Shapiro CM. Distinguishing sleepiness and fatigue: focus on definition and measurement. *Sleep Med Rev*. 2006;10(1):63-76.

22. Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness Scale. *Sleep*. 1991;14(6):540-545.
23. Johns MW. Reliability and factor analysis of the Epworth Sleepiness Scale. *Sleep*. 1992;15(4):376-381.
24. Tan AD, Novotny PJ, Kaur JS, et al. A patient-level meta-analytic investigation of the prognostic significance of baseline quality of life (QOL) for overall survival (OS) among 3,704 patients participating in 24 North Central Cancer Treatment Group (NCCTG) and Mayo Clinic Cancer Center (MC) oncology clinical trials. *J Clin Oncol*. 2008;26(15S):9515.
25. Gudex C, Dolan P, Kind P, Williams A. Health state valuations from the general public using the visual analogue scale. *Qual Life Res*. 1996;5(6):521-531.
26. Shanafelt TD, Novotny P, Johnson ME, et al. The well-being and personal wellness promotion strategies of medical oncologists in the North Central Cancer Treatment Group. *Oncology*. 2005;68(1):23-32.
27. Rummans TA, Clark MM, Sloan JA, et al. Impacting quality of life for patients with advanced cancer with a structured multidisciplinary intervention: a randomized controlled trial. *J Clin Oncol*. 2006;24(4):635-642.
28. Ware JE, Kosinski M, Dewey JE, Gandek B. *How to Score and Interpret Single-Item Health Status Measures: A Manual for Users of the SF-8 Health Survey*. Lincoln, RI: QualityMetric Inc; 2001.
29. Maslach C, Jackson SE, Leiter MP. *Maslach Burnout Inventory Manual*. 3rd ed. Palo Alto, CA: Consulting Psychologists Press; 1996.
30. Gopal R, Glasheen JJ, Miyoshi TJ, Prochazka AV. Burnout and internal medicine resident work-hour restrictions. *Arch Intern Med*. 2005;165(22):2595-2600.
31. Rosen IM, Gimotty PA, Shea JA, Bellini LM. Evolution of sleep quantity, sleep deprivation, mood disturbances, empathy, and burnout among interns. *Acad Med*. 2006;81(1):82-85.
32. Spitzer RL, Williams JB, Kroenke K, et al. Utility of a new procedure for diagnosing mental disorders in primary care: The PRIME-MD 1000 study. *JAMA*. 1994;272(22):1749-1756.
33. Whooley MA, Avins AL, Miranda J, Browner WS. Case-finding instruments for depression. Two questions are as good as many. *J Gen Intern Med*. 1997;12(7):439-445.
34. Williams JW Jr, Noel PH, Cordes JA, Ramirez G, Pignone M. Is this patient clinically depressed? *JAMA*. 2002;287(9):1160-1170.
35. Diggle PJ, Liang KY, Zeger SL. *Analysis of Longitudinal Data*. Oxford, England: Clarendon Press; 1994.
36. Liang KY, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika*. 1986;73(1):13-22.
37. Panlilio AL, Orelien JG, Srivastava PU, et al. Estimate of the annual number of percutaneous injuries among hospital-based healthcare workers in the United States, 1997-1998. *Infect Control Hosp Epidemiol*. 2004;25(7):556-562.
38. Henderson DK. Management of needlestick injuries: a house officer who has a needlestick. *JAMA*. 2012;307(1):75-84.
39. Gaba DM, Howard SK. Patient safety: fatigue among clinicians and the safety of patients. *N Engl J Med*. 2002;347(16):1249-1255.
40. Philibert I, Friedmann P, Williams WT, ACGME Work Group on Resident Duty Hours, Accreditation Council for Graduate Medical Education. New requirements for resident duty hours. *JAMA*. 2002;288(9):1112-1114.
41. Kellerman SE, Herold J. Physician response to surveys: a review of the literature. *Am J Prev Med*. 2001;20(1):61-67.
42. Handel DA, Raja A, Lindsell CJ. The use of sleep aids among emergency medicine residents: a web based survey. *BMC Health Serv Res*. 2006;6:136.
43. Gander P, Purnell H, Garden A, Woodward A. Work patterns and fatigue-related risk among junior doctors. *Occup Environ Med*. 2007;64(11):733-738.

Mayo Clin Proc. ■ December 2012;87(12):1138-1144 ■ http://dx.doi.org/10.1016/j.mayocp.2012.07.021
www.mayoclinicproceedings.org